Genetics, Sweet Preference, and Short Sleep: Important Players in Food Choice?

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  • Ohio Academy of Nutrition and Dietetics
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  • Monell Chemical Senses Center

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Today: Under-studied contributors to food choice

• Genetics: Sweet liking phenotype

• Sleep: Sweet preference, cravings, food reward
Sweet liking phenotypes (SLP)

- Phenotype: observable trait that results due to genetic and environmental interactions
- 3-4 “foundational” patterns of liking responses consistently reported\(^1\)
- SLP —> intake of total sugar,\(^2\) refined sugar,\(^2\) and sugar sweetened beverages.\(^3,4\)

\(^1\) Iatridi, Food Qual Pref, 2018; \(^2\) Holt, Food Qual Pref, 2000; \(^3\) Garneau, Food Qual Pref, 2018; \(^4\) Methven, Food Qual Pref, 2016

Likers consume more.
Sweet liking phenotypes (SLP)

• Recent review: SLP strengthens likelihood of identifying taste-dietary intake relationships
• Your interest: identifying different types of consumers

1. Tan and Tucker, Nutrients, 2019; HCA = Hierarchical Cluster Analysis
Adults – Differences in liking by concentration according to SLP

Mean overall liking of model solutions did not differ.

Garneau, et al., Food Qual Pref, 2018
Adults – Differences in liking by concentration according to SLP

Garneau, et al., Food Qual Pref, 2018
Liking differed significantly at all concentrations except 2.4%.

Garneau, et al., Food Qual Pref, 2018
Sweet Liking Phenotype predicts preferred sweetness concentrations for both sucrose and sucralose

<table>
<thead>
<tr>
<th>Habitual Cluster</th>
<th>Preferred Concentration (% w/v)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sucrose</td>
</tr>
<tr>
<td>Likers (n = 25)</td>
<td>14.9±4.4&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>“Non-likers” (n=15)</td>
<td>6.8±4.1&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Szczygiel, et al., Nutrients, 2019
Differences in liking by concentration according to Sweet Liking Phenotype

Sweetness Liking (15 cm line scale score) vs. Sucralose Concentration (%w/v)

Szczygiel, et al., Foods, 2019
## Prevalence of sweet liking phenotypes: Adults and children

<table>
<thead>
<tr>
<th>Study</th>
<th>Concentrations used (% w/v)</th>
<th>Sweet Likers (n,%)</th>
<th>Neutral/Inverted U-Shape (n,%)</th>
<th>Dislikers (n,%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Garneau et al, Food Qual Pref, 2018</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Adults (n=650)</td>
<td>0-13.7</td>
<td>218, 33.5%</td>
<td>377, 58.0%</td>
<td>55, 8.5%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>377, 58.0% includes 115, 30.5% U-shaped</td>
<td></td>
</tr>
<tr>
<td>• Children (ages 8 -18), n=303</td>
<td>0-13.7</td>
<td>237, 78.2%</td>
<td>-</td>
<td>66, 21.8%</td>
</tr>
</tbody>
</table>
Identifying SLPs: Best practices

• Lots of different ways to determine SLPs.
  • Visual inspection of slopes, cut-offs, hierarchical cluster analysis (HCA)
• Hayes et al. has proposed the use of the following concentrations\(^1\):
  • 0.03125, 0.0625, 0.125, 0.25, 0.5, 0.67, and 1 M
  • Equivalent to: 1.1%, 2.1%, 4.3%, 8.6%, 17.1%, 22.9%, 34.2% w/v
  • Use Hierarchical Cluster Analysis (HCA) – least biased

1. Hayes et al., Nutrients, 2019
Identifying SLPs: Faster approach?¹

Proposed cut-offs for 1 M (34.2% w/v)¹:
- Likers: +15 or greater
- U-shaped: <+15 - >-15
- Dislikers: > -15

1. Hayes et al., Nutrients, 2019; 2. Garneau et al, Food Qual Pref, 2018
Sweet Liking Phenotype summary

• Identifies sub-groups of the population
• Better predictor of dietary intake compared to other taste tests
• Use HCA to identify groups
• Possible to use cut-offs?
Pop quiz!

• How much sleep did you get last night?
  • A. Sleep, what’s that?
  • B. A solid 4-6 hours.
  • C. 7-9 hours.
  • D. 9+ hours.

If you answered A or B, count yourself as part of the 35% of Americans who do not routinely meet sleep recommendations of 7-9 h/night.
Sleep and chemosensory function

- Increased intake of high fat, high sugar foods after insufficient sleep\(^1-3\) —> weight gain
- Foods consumed —> typically selected based on their sensory properties (taste, smell, chemesthesis, texture, etc...)\(^4-6\)
- Does chemosensory function/perception change after insufficient sleep?
  - Focus: sweet taste
    - Sweet tasting foods are often high in added sugars, fats, and calories

• Research question: Are measures of sleep duration and quality associated with chemosensory function and perception?
  • Observational studies
Protocol

Recruitment
- Women*
- Ages 18-55
- BMI** < 30.0 kg/m²
- No diagnosed sleep disorders

Sleep Protocol
- One night, instructed to sleep normally
- Z-machine
- Measured: total sleep time, slow wave sleep, and REM sleep

Testing
- Sweet taste threshold (3-AFC, ascending method)
- Sweet taste preference (Monell FCPC)
- Olfactory threshold, recognition, and pleasantness (Sniffin’ Sticks)

*Higher incidence of insomnia (Zhang et al., Sleep, 2006); differences in sleep architecture (deeper sleepers) (Redline et al., JAMA Int Med, 2004)

**Deeper sleep among those with lower BMI (Redline et al., JAMA Int Med, 2004)
Sensitivity

• No correlation between any of the sleep variables and sweet taste sensitivity for either males or females.
## Relationships between sleep and preferred sucrose solution concentration

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pearson’s r</th>
<th>$R^2$</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Females (n=56)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TST</td>
<td>-0.35</td>
<td>0.12</td>
<td>0.0074**</td>
</tr>
<tr>
<td>REM</td>
<td>-0.41</td>
<td>0.16</td>
<td>0.0018**</td>
</tr>
<tr>
<td>SWS (N3)</td>
<td>-0.31</td>
<td>0.09</td>
<td>0.0221*</td>
</tr>
<tr>
<td>SWS + REM</td>
<td>-0.43</td>
<td>0.18</td>
<td>0.0008***</td>
</tr>
<tr>
<td><strong>Males (n=51)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TST</td>
<td>-0.35</td>
<td>0.12</td>
<td>0.0111*</td>
</tr>
<tr>
<td>REM</td>
<td>-0.49</td>
<td>0.24</td>
<td>0.0010**</td>
</tr>
<tr>
<td>SWS (N3)</td>
<td>-0.31</td>
<td>0.10</td>
<td>0.0248*</td>
</tr>
<tr>
<td>SWS + REM</td>
<td>-0.47</td>
<td>0.22</td>
<td>0.0005***</td>
</tr>
</tbody>
</table>

Multiple regression, best models:

- $F(2, 56) = 6.58, P = 0.0028$
- $F(2, 51) = 15.31, P = 0.0010$
Sleep duration and architecture

Females

Males

Preferred Sucrose Concentration (%w/v)

Longer Sleepers

Shorter Sleepers

Longer REM+SWS

Shorter REM + SWS

Longer Sleepers

Shorter Sleepers

Longer REM+SWS

Shorter REM + SWS

* * *
Observational studies summary: Sensitivity (function) not associated; taste hedonic effects?

Associations suggest that differences in sleep duration may contribute to differences in sweet taste liking or preference.
What happens if we intervene?

• Research question: Does sleep curtailment alter sweet taste function (intensity) or perception (hedonics: liking, preference)?
Research question: Does sleep curtailment alter sweet taste function or perception?

Secondary question: Do effects vary by sweetener?

- Sucrose vs. Sucralose (Splenda)

- Differential neural activation\(^1\)
  - Authors concluded: “Sucrose relative to sucralose (Splenda) elicits greater absolute brain response in the taste pathway and downstream reward system….”

1. Frank et al., Neurolmage, 2008
Assessed participants’ response to sucrose and sucralose after a habitual and curtailed night of sleep

- Consent Visit
- Week 1: Habitual night of sleep → Sensory evaluation
- Week 2: Curtailed night of sleep → Sensory evaluation

- Randomized
- Intensity
- Liking
- Preference

Szczygiel et al., Foods, 2019
Sleep curtailment

• Curtailment: 33% reduction based on self-reported habitual sleep duration
  • Better ecological validity than total deprivation.¹
    • Results in ~ 2-2.5 h reduction

1. Dinges, Sleep, 1987
Healthy participants were recruited and sleep curtailment was effective

<table>
<thead>
<tr>
<th>Objective Sleep Measures (h)</th>
<th>Habitual</th>
<th>Curtailed</th>
<th>% Reduction</th>
<th>Paired t-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time in bed</td>
<td>8.2±0.7</td>
<td>5.3±0.7</td>
<td>35.3%</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Total sleep time</td>
<td>7.0±0.8</td>
<td>4.5±0.8</td>
<td>36.0%</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Light sleep</td>
<td>3.6±0.7</td>
<td>2.0±0.6</td>
<td>44.2%</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>REM</td>
<td>1.9±0.5</td>
<td>1.1±0.3</td>
<td>40.4%</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Slow wave sleep</td>
<td>1.6±0.3</td>
<td>1.3±0.4</td>
<td>16.7%</td>
<td>0.0005</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Anthropometric and Demographic Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
</tr>
<tr>
<td>Male</td>
</tr>
<tr>
<td>Female</td>
</tr>
<tr>
<td>Race</td>
</tr>
<tr>
<td>White</td>
</tr>
<tr>
<td>Asian</td>
</tr>
<tr>
<td>Other/More than 1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Anthropometrics</th>
<th>Mean±SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body mass index (kg/m²)</td>
<td>22.9±3.0</td>
<td>18.5-29.7</td>
</tr>
<tr>
<td>Body fat (%)</td>
<td>22.3±7.9</td>
<td>9.9-35.5</td>
</tr>
<tr>
<td>Age (y)</td>
<td>23.8±4.6</td>
<td>18-37</td>
</tr>
</tbody>
</table>

Szczygiel et al., Nutrients, 2019
Intensity perception was not altered by sleep curtailment
Preferred sweetness concentration increased after sleep curtailment

Sucrose Concentration (%w/v)

Sucrose: ~ 45% increase

Szczygiel et al., Nutrients, 2019
Patterns of liking of sucrose altered after sleep curtailment

No difference in liking at each concentration

Significant difference in slope steepness

p=0.001

Szczygiel et al., Nutrients, 2019
When sucralose is used, the increase in slope steepness after curtailment is smaller

No difference in liking at each concentration

Slope: reduced effect when sucralose is tasted

p=0.129

Szczygiel et al., Nutrients, 2019
Sweet liking phenotypes → affected equally

- Insufficient sleep did not affect sweet likers and non-likers differently.
- Everyone is susceptible to the effects of sleep curtailment.
To summarize...

Sleep curtailment resulted in...

- Higher preferred sweetener concentration regardless of nutritive value
- Increased liking for sweeter stimuli - sucrose (increased slope steepness) • Changes in hedonic evaluation of sucralose less susceptible to sleep curtailment?
- No changes in sweet taste intensity perception

Szczygiel et al., Nutrients, 2019
How does sleep curtailment change food perception?

Model systems Vs. Complex Food

Research question: Do model system findings reflect hedonic response to complex foods? (Szczygiel, Cho, Tucker, Foods, 2019.)
Oat-based sweet food products were developed

Ingredients:
- Oats
- Sucralose
- Water

Confirmed Delicious (preliminary liking test n=20)

- Solids and liquids have different obesogenic capacity.

1. Tucker & Mattes, 2013
Oat-based food system

Macronutrient Composition of Oat Products

<table>
<thead>
<tr>
<th>Macronutrient</th>
<th>Oat Beverage</th>
<th>Oat Crisp</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 kcal</td>
<td>100 kcal</td>
<td></td>
</tr>
<tr>
<td>Fat</td>
<td>2 g</td>
<td>2 g</td>
</tr>
<tr>
<td>Carbohydrates</td>
<td>18 g</td>
<td>17 g</td>
</tr>
<tr>
<td>Protein</td>
<td>3 g</td>
<td>3 g</td>
</tr>
<tr>
<td>Crude Fiber</td>
<td>&lt;1 g</td>
<td>&lt;1 g</td>
</tr>
<tr>
<td>Moisture</td>
<td>189 g</td>
<td>1 g</td>
</tr>
<tr>
<td>Ash</td>
<td>&lt;1 g</td>
<td>&lt;1 g</td>
</tr>
</tbody>
</table>
Why use sucralose in the oat products?

- Disadvantages
  - Observed lessened effect of sleep curtailment in previous study; bias towards type II error?

- Advantages
  - Controls for other sensory properties across sweetness levels
  - Controls for energy across the products

Other reasons:
- Very commonly used sweetener
  - Most people exposed to sucralose daily in the developed world\(^1\)
- Flavor is experienced through multiple modalities, so the hedonic response to taste is influenced by other sensations.

1. Binns et. al. 2003
Assessed participants’ response to oat products after a habitual and curtailed night of sleep

- **Week 1**
  - Habitual night of sleep
  - Sensory evaluation of oat products
  - Randomized

- **Week 2**
  - 33% Curtailed night of sleep
  - Sensory evaluation of oat products

- **Consent Visit**

- **Features**
  - Flavor Liking
  - Overall Liking

Szczygiel et al., Foods, 2019
Healthy participants were recruited and sleep curtailment was effective

### Anthropometric and Demographic Summary

<table>
<thead>
<tr>
<th>Sex</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>15</td>
<td>37%</td>
</tr>
<tr>
<td>Female</td>
<td>26</td>
<td>63%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Race</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>27</td>
<td>66%</td>
</tr>
<tr>
<td>Asian</td>
<td>13</td>
<td>32%</td>
</tr>
<tr>
<td>Other/More than 1</td>
<td>1</td>
<td>2%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Anthropometrics</th>
<th>Mean±SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMI (kg/m²)</td>
<td>23.1±3.0</td>
<td>16.4-29.2</td>
</tr>
<tr>
<td>BF (%)</td>
<td>24.8±11.8</td>
<td>9.1-35.5</td>
</tr>
<tr>
<td>Age (y)</td>
<td>24.1±5.0</td>
<td>18-41</td>
</tr>
</tbody>
</table>

### Summary of Objective and Subjective Sleep Measures

<table>
<thead>
<tr>
<th>Objective Sleep Measures (h)</th>
<th>Habitual</th>
<th>Curtained</th>
<th>% Reduction</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time in Bed</td>
<td>8.3±0.7</td>
<td>5.4±0.7</td>
<td>34.90%</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Total Sleep Time</td>
<td>7.2±0.7</td>
<td>4.5±1.0</td>
<td>37.50%</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Light Sleep</td>
<td>3.8±0.5</td>
<td>2.0±0.8</td>
<td>47.40%</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>REM Sleep</td>
<td>1.9±0.5</td>
<td>1.2±0.4</td>
<td>36.90%</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Slow Wave Sleep</td>
<td>1.5±0.4</td>
<td>1.4±0.4</td>
<td>6.70%</td>
<td>0.043a</td>
</tr>
</tbody>
</table>

Szczygiel et al., Foods, 2019
Hedonic Response

Oat Beverage

Flavor Liking

Overall Liking

Significant increase in slope steepness after curtailment (p=0.017)

Significant increase in slope steepness after curtailment (p=0.047)

No effect of food form

Sucralose Concentration (%w/v)

Habitual

Curtailed

Szczygiel et al., Foods 2019
To summarize...

Sleep curtailment resulted in...

Increased **flavor** liking for sweeter versions of the two food products (increased slope steepness)

Increased **overall** liking for sweeter versions of the two food products (increased slope steepness)

Likely to see even larger changes if sucrose were used?
Sleep, hunger, & food reward

• Increased intake of high fat, high sugar foods after insufficient sleep\textsuperscript{1-3}

• Research question: Does sleep curtailment affect appetite, food reward, and/or food cravings?

Sleep, hunger, & food reward

- Females without obesity
- Two test visits
  - Habitual night’s sleep
  - Curtailed night’s sleep (33% reduction → ~ 2-2.5 h reduction)
- Same breakfast was consumed at the same time both days
- Came into the lab at the same time both days
- Appetite: rated how hungry they were – 100 mm VAS
- Cravings: General Food Cravings Questionnaire – State version
- Food reward: progressive ratio task where they could work for chocolate candy
Demographics

• N = 24

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (year)</td>
<td>24.4 ± 7.2</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>22.1 ± 2.6</td>
</tr>
<tr>
<td>Body fat (%)</td>
<td>25.8 ± 6.7</td>
</tr>
<tr>
<td>PSQI*</td>
<td>3.1 ± 1.1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Race (%)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>75.0</td>
</tr>
<tr>
<td>Asian</td>
<td>25.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ethnicity (%)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Hispanic</td>
<td>95.8</td>
</tr>
<tr>
<td>Prefer not to answer</td>
<td>4.2</td>
</tr>
</tbody>
</table>

*PSQI, Pittsburgh Sleep Quality Index.
Results: Sleep and Hunger

Sleep parameters from Z-machine

<table>
<thead>
<tr>
<th>Sleep parameter (h)</th>
<th>Habitual sleep</th>
<th>Curtailed sleep</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time in bed</td>
<td>8.19 ± 0.66</td>
<td>5.45 ± 0.56</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Total sleep time</td>
<td>7.03 ± 0.96</td>
<td>4.60 ± 0.72</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Slow wave/N3 sleep</td>
<td>1.49 ± 0.41</td>
<td>1.15 ± 0.41</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>REM sleep</td>
<td>2.03 ± 0.74</td>
<td>1.30 ± 0.48</td>
<td>&lt;0.001*</td>
</tr>
</tbody>
</table>

34.3% reduction

Effects of curtailed sleep on self-reported sleepiness, tiredness, quality of sleep, and hunger

<table>
<thead>
<tr>
<th></th>
<th>Habitual sleep</th>
<th>Curtailed sleep</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sleepiness</td>
<td>2.8 ± 1.3</td>
<td>4.9 ± 1.9</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Tiredness</td>
<td>24.8 ± 16.2</td>
<td>58.5 ± 15.3</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Quality of sleep</td>
<td>55.2 ± 17.2</td>
<td>43.0 ± 17.0</td>
<td>0.030*</td>
</tr>
<tr>
<td>Hunger</td>
<td>53.7 ± 16.9</td>
<td>60.8 ± 15.7</td>
<td>0.013*</td>
</tr>
</tbody>
</table>

Data expressed as: Mean ± SD.

Yang et al., Nutrients, 2019
Results: Cravings

Differences in G-FCQ-S after normal and curtailed sleep night

<table>
<thead>
<tr>
<th>Factor (max score for each factor = 15)</th>
<th>Normal sleep</th>
<th>Curtailed sleep</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>An intense desire to eat</td>
<td>9.5 ± 2.3</td>
<td>11.0 ± 1.9</td>
<td>0.009*</td>
</tr>
<tr>
<td>• I'm craving tasty food.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anticipation of relief from negative states and feelings as a result of eating</td>
<td>9.7 ± 2.3</td>
<td>11.1 ± 2.1</td>
<td>0.008*</td>
</tr>
<tr>
<td>• If I ate something, I wouldn’t feel so sluggish and lethargic.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Craving as a physiological state</td>
<td>9.9 ± 1.5</td>
<td>11.2 ± 1.8</td>
<td>0.009*</td>
</tr>
<tr>
<td>• If I ate right now, my stomach wouldn’t feel as empty.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Obsessive preoccupation with food or lack of control over eating</td>
<td>6.3 ± 2.4</td>
<td>7.7 ± 2.5</td>
<td>0.022*</td>
</tr>
<tr>
<td>• My desire to eat something tasty feels overpowering.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anticipation of positive reinforcement that may result from eating</td>
<td>10.0 ± 2.2</td>
<td>10.6 ± 1.9</td>
<td>0.236</td>
</tr>
<tr>
<td>• Eating something tasty would make things just perfect.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total score</td>
<td>45.5 ± 8.4</td>
<td>51.5 ± 7.4</td>
<td>0.002*</td>
</tr>
</tbody>
</table>

Data expressed as: Mean ± SD.
G-FCQ-S, General Food Cravings Questionnaire-State.

Food Reward: *Number of chocolate candies consumed increased (2.6 ± 0.9 vs. 3.3 ± 1.5, p = 0.004) under the curtailed sleep condition.
Conclusions

• Increased hunger, cravings, and food reward (willingness to work for palatable food) after **one** night of moderate sleep curtailment.

• All of these can contribute to increased intake.
Future directions

• Are the relationships observed present among people with obesity?
  • Individuals with obesity frequently sleep less and report lower sleep quality.
• Chronically short sleepers?
• Other taste qualities: salty
  • Does preferred salt concentration increase?
Summary

• 3-4 patterns of sweet liking.
  • Sweet likers tend to consume more sugar and sugar sweetened beverages.
  • Useful to separate consumers?
• Strong epidemiological and experimental evidence to suggest insufficient sleep increases the risk of weight gain and higher BMI.
  • Numerous mechanisms – including changes in hedonic processing, appetite, food reward, and food cravings.
• These changes in perception are likely part of the puzzle that explains relationships between insufficient sleep and alterations in food choice.
Collaborators for the work presented

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- Chia-Lun (Karen) Yang, M.S.
- Margaret Snyder
- Dr. Sungeun Cho
- Dr. Sze-Yen Tan